We Claim:

1. An adaptive four-wheel vehicle drive system comprising, in combination,

a primary drive line including a primary drive shaft and primary drive wheels,

a secondary drive line including a secondary drive shaft and secondary wheels,

a transfer case having a primary output shaft adapted to drive said primary drive wheels, a secondary output shaft adapted to drive said secondary drive wheels, modulating clutch means for selectively transferring torque from said primary output shaft to said secondary output shaft,

means for sensing the rotational speed of said primary drive line,

means for sensing the rotational speed of said secondary drive line, and

microcontroller means for comparing the speed of said primary drive line with the speed of said secondary drive line and incrementally engaging said modulating clutch means when the difference between said speeds is greater than a predetermined value and incrementally disengaging said modulating clutch means when said difference is less than said predetermined value.

2. The adaptive four-wheel vehicle drive system of Claim 1 wherein said primary drive line and primary drive wheels are at the rear of the vehicle and said secondary drive line and secondary drive wheels are at the front of the vehicle.

3. The adaptive four-wheel vehicle drive system of Claim 1 wherein said primary drive line and primary drive wheels are at the front of the vehicle and said secondary drive line and secondary drive wheels are at the rear of the vehicle.

4. The adaptive four-wheel vehicle drive system

of Claim 1 wherein said means for sensing are Hall effect sensors.

5. The adaptive four-wheel vehicle drive system of Claim 1 further including means for providing a signal to said microcontroller means indicating the position of the throttle.

6. The adaptive four-wheel vehicle drive system of Claim 1 further including means coupled to said microcontroller means for providing a signal when the vehicle brakes are applied.

7. The adaptive four-wheel vehicle drive system of Claim 1 further including a driven input shaft, a planetary gear speed reducing assembly coupled to said input shaft and having an output member, clutch means for selectively coupling said primary driven output shaft to either said input shaft or said output member of said planetary gear speed reducing assembly, drive means for positioning said clutch means and encoder means for providing data to said microcontroller means indicating the position of said clutch means.

8. The adaptive four-wheel vehicle drive system of Claim 1 further including a sensor indicating the position of the throttle and said microcontroller means includes means responsive to said throttle position sensor for incrementing said modulating clutch means.

9. The adaptive four-wheel vehicle drive system of Claim 1 wherein said transfer case is located adjacent a vehicle transmission and said primary drive line is driven by an output shaft of said transmission.

10. The adaptive four-wheel vehicle drive system of Claim 1 wherein said secondary drive line includes an axle engaging and disengaging means.

11. The adaptive four-wheel vehicle drive system of Claim 1 wherein said modulating clutch means is an electromagnetically actuated clutch.

12. The adaptive four-wheel vehicle drive system

of Claim 11 wherein said electromagnetically actuated clutch is driven by a PWM electrical current.

13. The adaptive four-wheel vehicle drive system of Claim 1 further including a transfer case housing and wherein said modulating clutch means is housed within said transfer case housing.

14. The adaptive four-wheel vehicle drive system of Claim 1 further including a secondary drive line differential having a housing and wherein said modulating clutch means is housed within said secondary differential housing.

15. The adaptive four-wheel vehicle drive system of Claim 1 further including axle engaging means coupled to said secondary drive wheels and means for selectively coupling said axle engaging means to said secondary drive line, wherein said microcontroller detects wheel slip and activates said modulating clutch means and said means for selectively coupling said axle engaging means when the difference between said speeds exceeds a second predetermined value during two-wheel drive operation.

16. The adaptive four-wheel vehicle drive system of Claim 15 wherein the microcontroller will disengage said means for engaging said secondary drive line after a predetermined period of inactivity of said modulating clutch means.

17. The adaptive four-wheel vehicle drive system of Claim 1 further including means for sensing the rotational speed of one of said secondary wheels.

18. The adaptive four-wheel vehicle drive system of Claim 1 wherein said predetermined value is dependent upon brake application.

19. The adaptive four-wheel vehicle drive system of Claim 1 wherein said predetermined value is a function of vehicle speed.

20. The adaptive four-wheel vehicle drive system

of Claim 1 wherein said predetermined value is dependent upon the identity of the overrunning drive line.

21. The adaptive four-wheel vehicle drive system of Claim 1 wherein said predetermined value is dependent upon application of the brakes of the vehicle.

22. The adaptive four-wheel vehicle drive system of Claim 1 further including means for sensing the speed of a secondary wheel and tire assembly and means for sequentially engaging a secondary drive line axle engaging means and said modulating clutch means.

23. The adaptive four-wheel vehicle drive system of Claim 1 wherein the speed of said primary drive line is measured by measuring the speed of said primary output shaft and the speed of said secondary drive line is measured by measuring the speed of said secondary output shaft.

24. The adaptive four-wheel vehicle drive system of Claim 1 wherein said means for sensing the rotational speeds of said primary and said secondary drive lines are disposed in said transfer case.

25. In an adaptive vehicle drive system including a primary drive shaft coupled to a primary differential having an output coupled to a primary pair of driven wheels, a secondary drive shaft coupled to a secondary differential having an output coupled to a secondary pair of driven wheels, the improvement comprising,

a transfer case having a driven input shaft, a planetary gear speed reducing assembly coupled to said input shaft and having an output member, a primary output shaft coupled to said primary drive shaft, clutch means for selectively coupling said primary output shaft to one of said input shaft and said output member, a secondary output shaft coupled to said secondary drive shaft, modulating clutch means for

selectively coupling said primary output shaft to said secondary output shaft,

means for sensing the rotational speed of said primary output shaft,

means for sensing the rotational speed of said secondary output shaft, and

a microcontroller including means for comparing the speed of said primary output shaft and said secondary output shaft and incrementally engaging said modulating clutch when the difference between said speeds exceeds a predetermined value.

26. The adaptive vehicle drive system of Claim 25 further including drive means for positioning said clutch means and encoder means for reading the position of said clutch means and providing data indicating the position of said clutch means to said microcontroller.

27. The adaptive vehicle drive system of Claim 25 further including means for providing a signal to said microcontroller indicating the position of the vehicle throttle.

28. The adaptive vehicle drive system of Claim 25 further including means coupled to said microcontroller for providing a signal when the vehicle brakes are applied.

29. The adaptive vehicle drive system of Claim 25 wherein said primary drive shaft and driven wheels are at the rear of the vehicle and said secondary drive shaft and secondary driven wheels are at the front of the vehicle.

30. The adaptive vehicle drive system of Claim 25 wherein said means for sensing are Hall effect sensors.

31. The adaptive vehicle drive system of Claim 25 wherein said predetermined value varies with vehicle speed.

32. The adaptive vehicle drive system of Claim 25 wherein said predetermined value is a function of front

wheel and rear wheel overrun.

33. The adaptive vehicle drive system of Claim 25 wherein said modulating clutch increments and decrements in six to ten steps.

34. The adaptive vehicle drive system of Claim 25 further including PWM drive means for providing a minimum current to the modulating clutch means of approximately ten percent.

35. A torque distributing system for a vehicle comprising, in combination,

a first drive shaft coupled to a first differential having an output coupled to a first pair of drive wheels,

a second drive shaft coupled to a second differential having an output coupled to a second pair of drive wheels,

a transfer case having a first output shaft coupled to said first drive shaft, a second output shaft coupled to said second drive shaft, clutch means for selectively transferring torque from said first output shaft to said second output shaft,

means for sensing the rotational speed of said first output shaft and providing a first speed signal,

means for sensing the rotational speed of said second output shaft and providing a second speed signal, and

a microcontroller including first means for determining the speed of such vehicle from said first signal, second means for computing the difference between said first and said second speed signals, third means for generating a clutch incrementing signal when said speed difference exceeds a predetermined value related to said vehicle speed and fourth means for generating a clutch decrementing signal when said speed difference no longer exceeds said predetermined value.

36. The torque distributing system of Claim 35

wherein said first drive shaft and driven wheels are at the rear of the vehicle and said second drive shaft and driven wheels are at the front of the vehicle.

37. The torque distributing system of Claim 35 wherein said first drive shaft and driven wheels are at the front of the vehicle and said second drive shaft and driven wheels are at the rear of the vehicle.

38. The torque distributing system of Claim 35 further including means for selectively coupling said output of said second differential to said second pair of driven wheels.

39. The torque distributing system of Claim 38 wherein said means for selectively coupling further includes a front axle disconnect.

40. The torque distributing system of Claim 38 further including a pair of locking hubs.

41. The torque distributing system of Claim 35 wherein said means for sensing are Hall effect sensors.

42. The torque distributing system of Claim 35 wherein said clutch increments and decrements in eight steps.

43. The torque distributing system of Claim 35 further including means for providing a signal to said microcontroller indicating the position of the vehicle throttle.

44. The torque distributing system of Claim 35 further including means for sensing the rotational speed of one of said second pair of drive wheels.

45. An adaptive four-wheel vehicle drive system comprising, in combination,

a primary drive shaft coupled to a primary differential having an output coupled to a primary pair of drive wheels,

a secondary drive shaft coupled to a secondary differential having an output coupled to a secondary pair of drive wheels,

a transfer case having a primary output shaft coupled to said primary drive shaft, a secondary output shaft coupled to said secondary drive shaft, modulating electromagnetic clutch means for selectively transferring torque from said primary output shaft to said secondary output shaft,

sensor means for determining vehicle conditions, and

control means for providing a predetermined minimum current to said electromagnetic clutch means to maintain said clutch means, said secondary drive shaft and said secondary differential in a staged condition.

46. The adaptive four-wheel drive system of Claim 45 wherein said predetermined minimum current is 10% of maximum nominal current.

47. The adaptive four-wheel vehicle drive system of Claim 45 wherein said sensor means includes a first means for sensing the speed of said primary drive shaft and second sensor means for sensing the speed of said secondary drive shaft.

48. The adaptive four-wheel vehicle drive system of Claim 45 further including a planetary gear assembly having a first, direct drive output and a second, slow speed output.

49. The adaptive four-wheel vehicle drive system of Claim 45 wherein said transfer case further includes an input shaft, a speed reducing assembly coupled to said input shaft and having an output member, clutch means for selectively coupling said primary drive shaft to said input shaft, said output member of said speed reducing assembly or neither said input shaft or said output member, means for positioning said clutch means, and encoder means for reading the position of said positioning means and providing data to said microcontroller.

50. An adaptive four-wheel vehicle drive system

comprising, in combination,

a primary drive shaft coupled to a primary differential having an output coupled to a primary pair of driven wheels,

a secondary drive shaft coupled to a secondary differential having an output coupled to a secondary pair of driven wheels through an axle engaging and disengaging means,

a transfer case having a primary output shaft coupled to said primary drive shaft, a secondary output shaft coupled to said secondary drive shaft, modulating clutch means for selectively transferring torque from said primary output shaft to said secondary output shaft,

sensor means for determining vehicle conditions, and

microcontroller means for applying a minimum level of current to said modulating clutch, engaging said secondary axle engaging and disengaging means and inhibiting incrementing of said modulating clutch for a predetermined time period.

51. The adaptive vehicle drive system of Claim 50 further including sensing means providing a signal to said microcontroller which indicating that said primary pair of driven wheels are spinning and the vehicle is not moving and wherein said microcontroller includes means for effecting engagement of said axle engaging and disengaging means before said modulating clutch is incremented.

52. The adaptive vehicle drive system of Claim 51 wherein said sensing means includes a Hall effect sensor associated with one of said secondary pair of driven wheels.

53. The adaptive vehicle drive system of Claim 51 wherein said sensor means includes a first means for sensing the speed of said primary drive shaft and

second sensor means for sensing the speed of said secondary drive shaft.

54. The adaptive vehicle drive system of Claim 51 further including means for providing a signal to said microcontroller indicating that the brakes are applied.

55. An adaptive four-wheel drive system including a transfer case component for four-wheel drive operation having a primary output shaft and a secondary output shaft, an adjustable clutch, and means for controlling operation of said clutch in response to a demand for increased torque, said means for controlling clutch operation comprising:

means for providing a measure of primary output shaft speed,

means for providing a measure of secondary output shaft speed,

means for determining a desired speed difference between said primary output shaft speed and said secondary output shaft speed,

means for determining a measure of the speed difference between said primary output shaft speed and said secondary output shaft speed,

means for comparing said desired speed difference and said measured actual speed difference to provide an error signal representative of the difference between said desired speed difference and said measured actual speed difference,

means responsive to said error signal for providing an output signal representatives of a required clutch engagement rate to allow said clutch to engage at a required controlled amount to facilitate a coupling of said primary output shaft and said secondary output shaft.

56. The system of Claim 55 wherein said output signal is representative of a required clutch disengagement rate to allow said clutch to disengage to

facilitate decoupling of said primary output shaft and said secondary output shaft.

57. The system of Claim 56 wherein said output signal is representative of a required clutch disengagement rate to allow said clutch to slip at a controlled rate to facilitate decoupling of said primary output shaft and said secondary output shaft.

58. The system of Claim 55 wherein said clutch is incrementally coupled in response to said output signal.

59. The system of Claim 55 wherein said clutch is incrementally disengaged in response to said output signal.

60. The system of Claim 55 wherein said error signal is further modified in response to alteration of said actual speed difference.

61. The system of Claim 55 wherein said adjustable clutch is an electromagnetic clutch, said clutch being adjusted by modulation of an electronic signal input.

62. In an adaptive four-wheel drive system including a torque distributing system for four-wheel drive operation having a primary drive and a secondary drive line, clutch means associated with said secondary drive line, and means for controlling operation of said clutch means in response to predetermined conditions, a method for controlling clutch operation comprising:

determining primary drive line speed,

determining secondary drive line speed,

determining the speed difference between said primary drive line speed and said secondary drive line speed,

comparing a desired speed difference and said determined speed difference to provide a signal representative of the difference between said desired speed difference and said determined speed difference,

engaging said clutch at a predetermined rate to transfer torque from said primary drive line to said secondary drive line.

63. The method of Claim 57 wherein said engaging of said clutch is achieved incrementally.

64. The method of Claim 57 further including the step of incrementally disengaging said clutch.

65. A torque distribution system for coupling a torque input source to a torque output, comprising:

rotatable primary and secondary output shafts,

adjustable clutch means for selectively drivingly coupling said primary and secondary output shafts,

control means responsive to the speed difference between said primary and secondary drive shafts, said control means providing incremental engagement of said adjustable clutch means in response to a measured actual speed difference between said drive shafts being greater than a predetermined desired speed difference between said drive shafts.

66. The torque distribution system of Claim 65 further including a two speed planetary gear assembly operably coupled to said torque input source.

67. An adaptive four-wheel vehicle drive system comprising, in combination,

a primary drive line having primary drive wheels,

a secondary drive line having secondary drive wheels,

a transfer means having a primary output shaft adapted to drive said primary drive wheels, a secondary output shaft adapted to drive said secondary drive wheels,

modulating clutch means for selectively transferring torque from said primary drive line to said secondary drive line,

means for sensing the rotational speed of said primary drive line,

means for sensing the rotational speed of said secondary drive line, and

microcontroller means for comparing the speed of said primary drive line with the speed of said secondary drive line and incrementally engaging said modulating clutch means when the difference between said speeds is greater than a predetermined value.

68. The adaptive four-wheel vehicle drive system of Claim 62 wherein said microcontroller also incrementally disengages said modulating clutch means when said difference is less than said predetermined value.

69. A method of controlling torque delivery in a four-wheel vehicle drive system comprising the steps of:

sensing the speed of a primary drive line having a primary drive shaft and primary drive wheels and providing a primary speed signal,

sensing the speed of a secondary drive line having a secondary drive shaft and secondary drive wheels and providing a secondary speed signal,

comparing said primary speed signal and said secondary speed signal to determine a difference value, and

incrementally engaging a clutch to transfer torque from said primary drive line to said secondary drive line when said difference value exceeds a predetermined value dependent upon vehicle speed and incrementally disengaging said clutch when said difference value is less than said predetermined value.

70. The method of Claim 69 wherein said predetermined value is also dependent upon application of the vehicle brakes.

71. The method of Claim 69 wherein said predetermined value is also dependent upon the position of the throttle.

72. The method of Claim 69 wherein said predetermined value is also dependent upon the angular position of the front wheels of the vehicle.

73. The method of Claim 69 wherein said primary drive line is disposed at the rear of a vehicle.

74. The method of Claim 69 wherein said step of incrementally engaging said clutch comprehends at least six steps between minimum clutch engagement and maximum clutch engagement.

75. The method of Claim 69 further including the step of sensing the speed of one of said secondary drive wheels and sequentially engaging a secondary drive line axle engaging means and incrementally engaging said clutch.

76. A transfer case for use in a four-wheel drive vehicle comprising, in combination,

an input shaft,

a primary output shaft,

a secondary output shaft,

a speed reducing assembly coupled to said input shaft and having an output member, clutch means for selectively coupling said primary output shaft to either said input shaft or said output member of said speed reducing assembly, electric drive means for positioning said clutch means and encoder means for providing data indicating the position of said clutch means,

modulating clutch means operably disposed between said primary output shaft and said secondary output shaft for providing incremental levels of torque transfer between said primary output shaft and said secondary output shaft, said modulating clutch means including a disc pack clutch operably disposed between said primary output shaft and said secondary output shaft, and means for incrementally engaging said disc pack clutch.

77. The transfer case of Claim 76 further including means for sensing the speed of said primary output shaft and said secondary output shaft.

78. The transfer case of Claim 77 further including a housing and wherein said means for sensing are Hall effect sensors disposed in said housing.

79. The transfer case of Claim 76 wherein said means for engaging includes an electromagnetic coil disposed in operating relationship with means for activating said disc pack clutch.

80. The transfer case of Claim 76 wherein said electric drive means includes a bi-directional motor and said encoder data indicates at least high, neutral and low positions of said speed reducing assembly.

81. The transfer case of Claim 76 wherein said speed reducing assembly is a planetary gear assembly.